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INSTRUCTION MANUAL

KEPCO®

THE POWER SUPPLIER™

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KEPCO, INC.

TMA
POWER MODULE CONTROLLER

INTERACTIVE DIGITALLY CONTROLLED POWER MODULE SYSTEM

Model TMA 488-27

OPERATOR'S MANUAL

The Kepco equipment described in this Operator's Manual is of proprietary design.

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TABLE OF CONTENTS

PARAGRAPH		PAGE
	SECTION I - OVERVIEW	
1-1	Introduction to ATLAS, CIIL, and MATE in a Test System Environment	1-1
1-3	ATLAS	1-1
1-4	CIIL	1-1
1-5	MATE	1-2
1-6	MATE Modules	1-2
1-7	TMA/MAT Module Configuration	1-2
	SECTION II - INTRODUCTION	
2-1	Scope of Manual	2-1
2-3	General Description	2-1
2-5	IEEE 488 Interface Functions	2-1
2-6	TMA/MAT Commands	2-1
2-7	Control Bus	2-1
2-9	Specifications, General	2-2
2-10	System Diagram	2-2
2-11	The Host Computer	2-2
	SECTION III - PREPARATION FOR USE	
3-1	Unpacking and Inspection	3-1
3-4	Installation	3-1
3-6	Set Device Address and Shield Ground Selection	3-1
3-8	Installation of the TMA 488-27	3-1
3-10	Preparation and Installation of the Kepco Cable Assemblies	3-1
3-12	Final System Interconnections	3-1
3-14	Rear Terminals on the TMA 488-27	3-2
	SECTION IV - OPERATION	
4-1	General	4-1
4-4	Communications	4-1
4-7	Using the RS232 Serial Communication Bus	4-1
4-8	Using the IEEE 488 GPIB	4-2
4-9	CIIL Codes	4-3
4-10	CIIL Operation Codes	4-4
4-11	The Function Command	4-4
4-12	FNC Operation Code	4-4
4-13	The SET, SRX, and SRN Commands	4-5
4-14	SET Operation Code	4-5
4-15	The Open/Close Relay Commands	4-6
4-16	OPN/CLS Operation Codes	4-6
4-17	The RESET Command	4-6

SECTION IV - OPERATION (CONT'D)

4-18 RST Operation Code 4-6
4-19 The Confidence Test Command 4-6
4-20 CNF Operation Code 4-6
4-21 Internal Self Test Command 4-6
4-22 IST Operation Code 4-6
4-23 Status Command 4-6
4-24 STA Operation Code 4-6
4-25 Initiate Command 4-7
4-26 INX Operation Code 4-7
4-27 The FETCH Command 4-7
4-28 FTH Operation Code 4-7
4-29 Go To Alternate Language Command 4-7
4-30 GAL Operation Code 4-7
4-31 Non-CIIL Commands 4-7
4-32 Error Handling Commands 4-7
4-33 Error Handling Operation Codes 4-7
4-34 Service Request and Serial Poll Commands 4-8
4-35 Service Request and Serial Poll Operation Codes 4-8
4-36 Relay Error Commands 4-8
4-37 Relay Error Operation Codes 4-8
4-38 Return to CIIL Command 4-8
4-39 Return to CIIL Operation Code 4-8
4-40 CIIL Bus Transmission Format 4-9
4-42 Response Message Syntax 4-9
4-44 Condition Normal 4-9
4-45 Condition Abnormal 4-10
4-46 Error Messages 4-10
4-47 Error Message Priority 4-11
4-49 Catastrophic Error Handling 4-11
4-51 The Discrete Fault Line 4-11
4-52 MATE system Applications 4-11
4-53 Non-MATE System Applications 4-11
4-54 General Programming Comments 4-12
4-55 Successful Intercommunications 4-12
4-57 Sample Basic Program And Flow Diagram 4-12

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LIST OF ILLUSTRATION

FIGURE		PAGE
1-1	Atlas System	1-1
1-1	Atlas System With CIIL Implemented	1-2
2-1	Front and Back Panel for TMA 488-27 Power Module Controller	2-3
2-2	Block Diagram of the TMA 488-27 Power Module Controller in Test Setup	2-4
3-1	Back Panel of TMA 488-27 Power Module Controller	3-4
3-2	Installations Drawing (Mechanical Outlines)	3-5/3-6
4-1	Status Byte Configuration	4-8
4-2	Flow Diagram for the Sample Basic Program	4-13
4-3	Sample Basic Program for the TMA 488-27 / MAT System	4-14

LIST OF TABLES

TABLE		PAGE
2-1	Interface Functions of the TMA 488-27 Power Module Controller	2-1
2-2	General Specifications for TMA 488-27 Power Module Controller	2-2
3-1	Valid Addresses for the TMA 488-27 Power Module Controller	3-2
3-2	Specifications of the Control Bus Cable	3-3
4-1	Computer Terminals for the TMA 488-27 Power Module Controller	4-2
4-2	Interface Functions for the GPIB Implemented for the TMA 488-27 Power Module Controller	4-2
4-3	Command Mode Messages of the TMA 488-27 Power Module Controller on the IEEE 488	4-3
4-4	Data Mode Messages of the TMA 488-27 Power Module Controller on the IEEE 488	4-3

SECTION I - OVERVIEW

1-1 INTRODUCTION TO ATLAS, CIIL AND MATE IN A TEST SYSTEM ENVIRONMENT

1-2 Kepco's TMA 488-27 Power Module Controller is designed to be versatile. It can be used in a MATE system, and it can also be used in a non-MATE environment. The following sections give a detailed description concerning the use of the Kepco TMA 488-27 Power Module Controller. This section is an introductory overview of an automatic test system environment.

1-3 ATLAS stands for Abbreviated Test Language for All Systems. ATLAS is a high level language used in automatic test systems. A typical configuration for an automatic test system using ATLAS is illustrated in FIG. 1-1. In this system, the interface between the Host Computer and the "modules" or test instruments is the IEEE 488 GPIB. The IEEE 488 GPIB is the "highway" for communications between the computer and test instruments. The Host Computer converts from ATLAS to each test instrument's specific "native" code. The instrument's specific codes are manufacturer defined. That is each test instrument's instruction set may not be compatible with other manufacturer's codes. Hence conversion from one to another is very time consuming and costly.

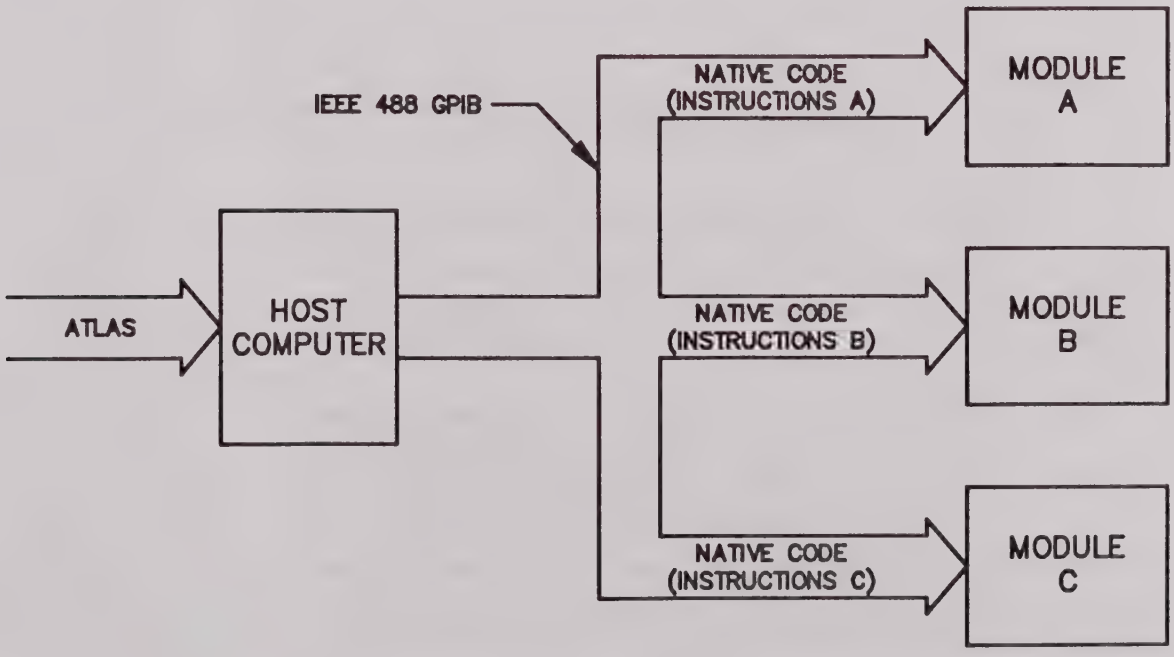


FIGURE 1-1 A HOST COMPUTER GENERATES THE "NATIVE" COMPUTER CODES FOR EACH MODULE ON THE IEEE 488 GENERAL PURPOSE-INTERFACE BUS

1-4 With the advent of CIIL (Control Interface Intermediate Language), defined by the Military Standard 2806763 Rev. C, any CIIL instrument's code can run another CIIL comprehendible machine of the same type. The IEEE 488 is still the "highway", but now CIIL is the "law enforcement" of the "highway". The Host Computer must still convert from ATLAS to the test instruments instruction code but now one set of instructions is all that's needed. An example of a test system implementing CIIL is represented in FIG. 1-2. With the advent of CIIL,

one test systems's software can be implemented in another test system with a minimum of changes.

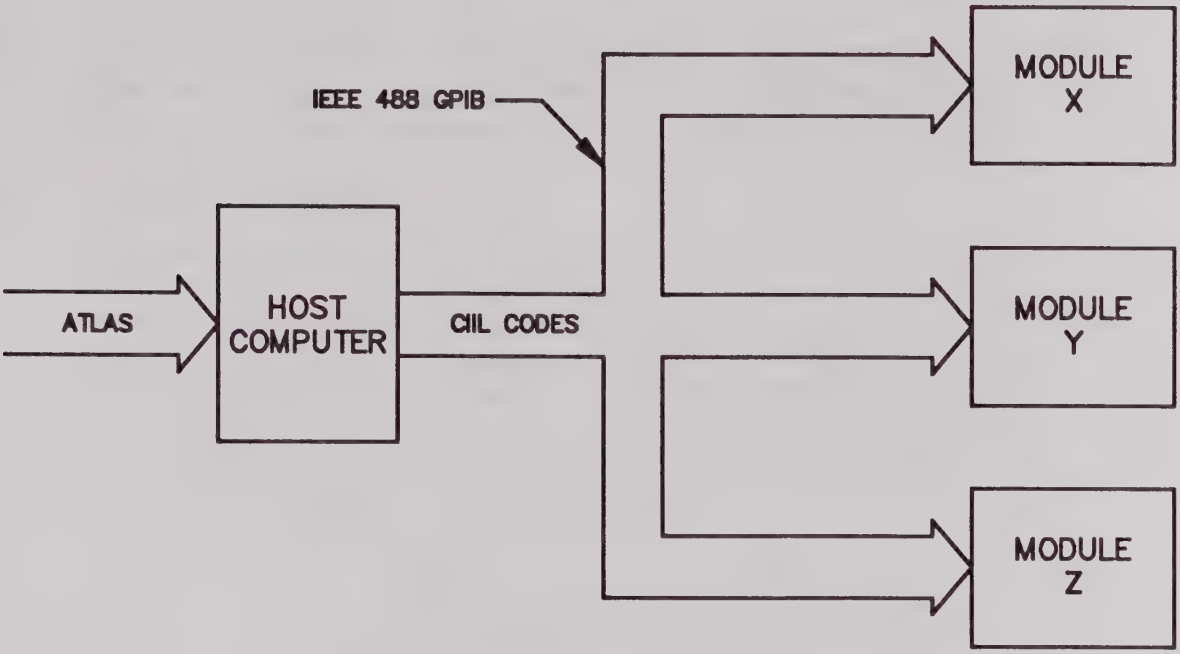


FIGURE 1-2 CIIL (CONTROL INTERFACE INTERMEDIATE LANGUAGE) COMPATIBLE MODULES SIMPLIFY PROGRAMMING TASKS.

1-5 MATE or Modular Automated Test Equipment is a complete automated test system.

1-6 Every instrument connected to the GPIB is considered a Module. There are seven types of Modules, but only the most general ones are discussed in this manual, (for an extensive analysis, see the MATE manual). The three most basic modules are: the Sensor, Stimulus and Switching modules.

A Sensor Module is capable of measuring or capturing the numerical value of a signal

A Stimulus Module is capable of producing a controlled signal.

A Switching Module is capable of routing a path for a signal to travel from a Unit Under Test (UUT) to a Module (sensor) or from a Module (stimulus) to a UUT.

1-7 The TMA/MAT system combines two modules, making up a hybrid of the Stimulus and the Sensor modules. The system supplies power, providing a stimulus similar to Kepco's earlier MATE systems. But now the system can capture output values which makes the TMA/MAT system a sensor module also.

1-8 A Module can further be broken down into two sections, a Control Section and a Functional Section. In the TMA/MAT system the TMA controller interprets CIIL commands (the control Section), whereas the MAT power modules execute the CIIL commands (the Functional Section).

A module has two types of ports, "Primary Port" and "Secondary Port".

A Primary Port is an input or output of a module's control or functional subsections.

Secondary Port is a dedicated input or output of a module. A dedicated signal may trigger an event (output) or it may be triggered by an event (input).

SECTION II - INTRODUCTION

2-1 SCOPE OF MANUAL

2-2 This operator's manual contains the specifications and instructions for the installation and operation of the Model TMA 488-27 Power Module Controller, manufactured by Kepco, Inc. Flushing, N.Y. U.S.A.. For extended technical information see the Kepco TMA 488-27 Service Manual.

2-3 GENERAL DESCRIPTION

2-4 The Kepco model TMA 488-27 is a Power Module Controller which has the capability to program, control and monitor the outputs of up to 27 Kepco "MAT" power modules up to a maximum distance of 1000 feet (300 meters). The TMA 488-27 communicates with its Host computer over a IEEE 488 (GPIB) using the MATE Control Interface Intermediate Language (CIIL). The controller provides a separate MATE compatible Discrete Fault Line (Line Status Monitor). An auxiliary input port allows for the RS 232 (EIA 232) standard serial communications bus. The TMA 488-27 communicates with the MAT series using a proprietary two-wire serial bus, hereafter referred to as the Control Bus.

GPIB FUNCTION	SUBSET SYMBOL
Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T6
Listener	L4
Service Request	SR1
Remote Local	RL2
Parallel Poll	PP0
Device Clear	DC1
Device Trigger	DT0
Controller	C0

TABLE 2-1 TMA 488-27 INTERFACE FUNCTIONS FOR IEEE 488

2-5 The IEEE-488 interface functions implemented by the controller are as follows: SH1, AH1, T6, L4, SR1, RL2, PP0, DC1, DT0 and C0. For a description of these GPIB functions, which are defined by the IEEE 488 Standard, see Table 2-1.

2-6 The TMA 488-27 accepts and interprets thirteen commands, they are as follows: FUNCTION, SET, SET MAXIMUM, SET MINIMUM, INITIATE, FETCH, CLOSE, OPEN, INTERNAL SELF TEST, CONFIDENCE TEST, STATUS, RESET, and GO TO ALTERNATE LANGUAGE. The controller recognizes one NOUN and four NOUN MODIFIERS: DIRECT CURRENT SOURCE, VOLTAGE, VOLTAGE LIMIT, CURRENT and CURRENT LIMIT respectively.

2-7 To connect the TMA 488-27 with the MAT power modules a shielded two (2) wire twisted-pair cable is used. The interconnection from controller to Host Computer on the GPIB is done via the IEEE 488 standard bus cable. If the serial port is used for communications between

the controller and a computer terminal, a standard 25 position RS 232 connector/cable is required. The Discrete Fault Line uses a 2 position connector.

2-8 The TMA 488-27 consists of a single-board computer (SBC) housed in a 1 23/32" high, by 19" wide by 15" deep case.

2-9 **SPECIFICATIONS, GENERAL: Refer to FIG. 2-1 and Table 2-2**

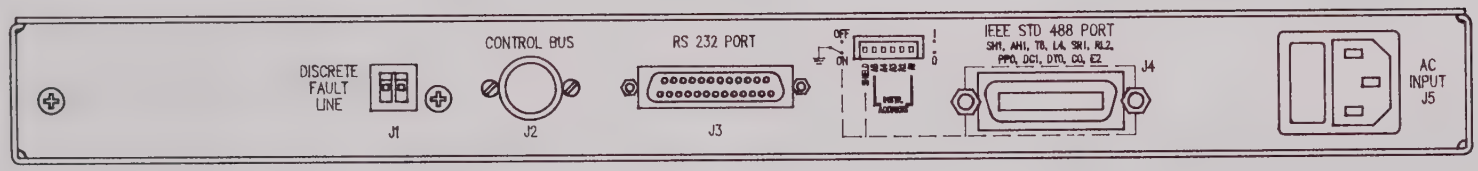
TMA 488-27 FEATURE	SPECIFICATION
AC input requirements	95 to 264 Vac, 47 To 63Hz approximately 50 W maximum
Ambient operating temperature range	0 to +55℃
Storage temperature range	-20 to +75℃
Dimensions	$1\frac{23}{32}$" H × 19"W × 15"D
Weight	Approximately 7 Lbs.
Color (front panel)	Kepco grey, Hartin Paint No. 15-22493
Mounting	19" rack (inserts are provided for chassis slide mounting)

TABLE 2-2 GENERAL SPECIFICATIONS FOR MODEL TMA 488-27

2-10 The **BLOCK DIAGRAM** (FIG. 2-2) shows a typical test set up under the direction of a Host Computer. The additional two lines to the Host Computer transmit a contact closure in case of a serious malfunction in one of the power modules.

2-11 The **HOST COMPUTER** can set the output voltage with current limit, or the output current with voltage limit. It then can have the TMA 488-27 read back the actual output voltage and current delivered by each of the "MAT" power modules to their respective loads. The TMA 488-27 is continually polling all of the power modules on the Control Bus for flags of catastrophic and noncatastrophic errors. All data transmissions over the GPIB are ASCII encoded. The values for the command parameters can be written in integer, decimal or scientific notation. The responses from the TMA 488-27 are detailed in Section IV of this manual.

FRONT PANEL



REAR PANEL

FIGURE 2-1 FRONT AND REAR PANEL OF TMA 488-27 POWER MODULE CONTROLLER

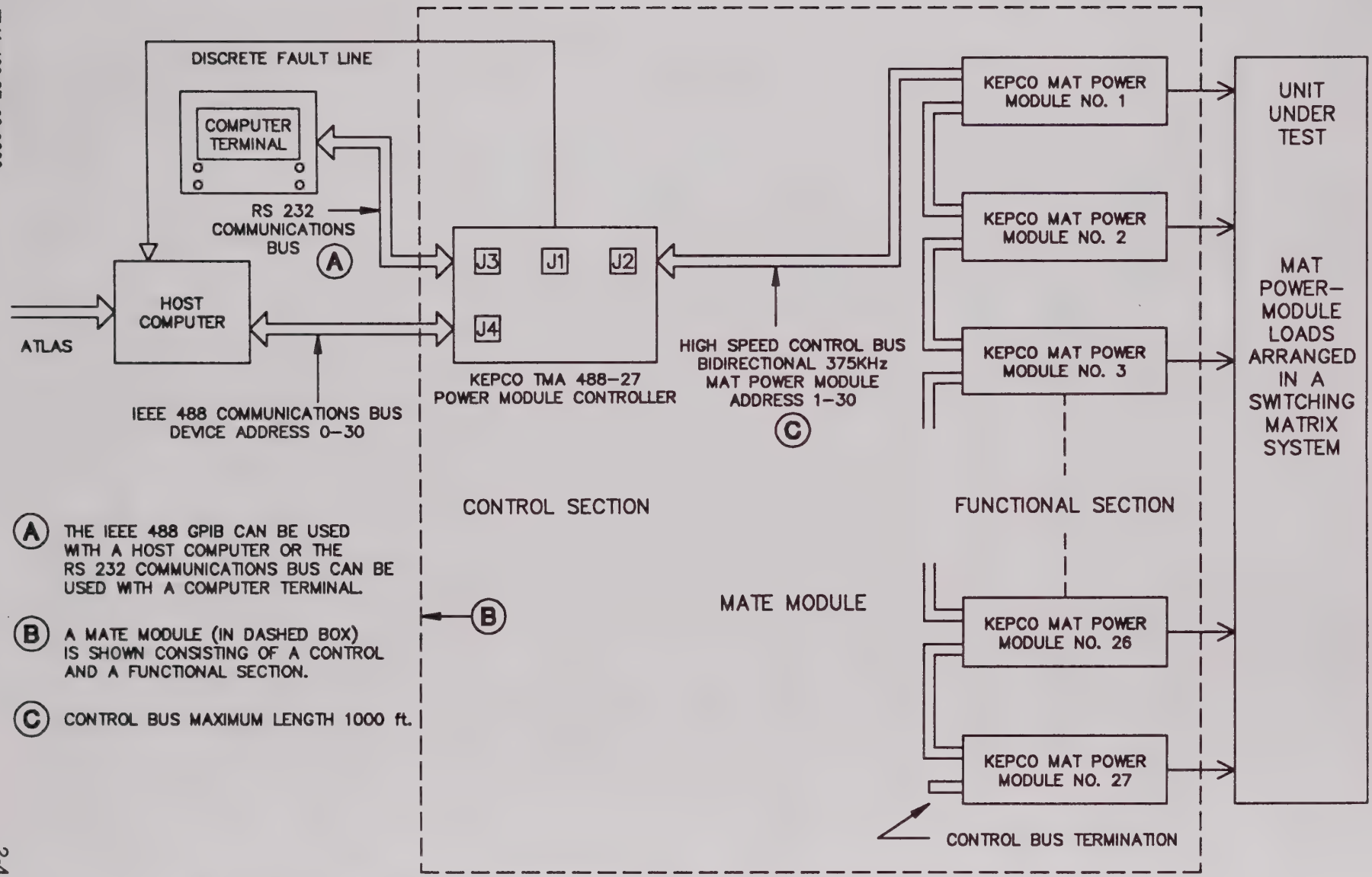

DISCRETE FAULT LINE
COMPUTER TERMINAL
RS 232 COMMUNICATIONS BUS
A
HOST COMPUTER
ATLAS
IEEE 488 COMMUNICATIONS BUS DEVICE ADDRESS 0–30
J3
J1
J2
J4
KEPCO TMA 488–27 POWER MODULE CONTROLLER
HIGH SPEED CONTROL BUS BIDIRECTIONAL 375KHz MAT POWER MODULE ADDRESS 1–30
C
KEPCO MAT POWER MODULE NO. 1
KEPCO MAT POWER MODULE NO. 2
KEPCO MAT POWER MODULE NO. 3
KEPCO MAT POWER MODULE NO. 26
KEPCO MAT POWER MODULE NO. 27
CONTROL BUS TERMINATION
UNIT UNDER TEST
MAT POWER–MODULE LOADS ARRANGED IN A SWITCHING MATRIX SYSTEM
CONTROL SECTION
FUNCTIONAL SECTION
MATE MODULE
B
A THE IEEE 488 GPIB CAN BE USED WITH A HOST COMPUTER OR THE RS 232 COMMUNICATIONS BUS CAN BE USED WITH A COMPUTER TERMINAL.
B A MATE MODULE (IN DASHED BOX) IS SHOWN CONSISTING OF A CONTROL AND A FUNCTIONAL SECTION.
C CONTROL BUS MAXIMUM LENGTH 1000 ft.

FIGURE 2-2 BLOCK DIAGRAM OF A TMA 488-27/MAT DIGITALLY CONTROLLED POWER MODULE SYSTEM SHOWING INTERFACE CONNECTIONS BETWEEN A HOST COMPUTER, THE TMA 488-27, AND KEPCO MAT SERIES POWER MODULES

SECTION III - PREPARATION FOR USE

3-1 UNPACKING AND INSPECTION

3-2 The Model TMA 488-27 has been carefully inspected and tested prior to packing. Inspect the shipping carton immediately upon receipt for evidence of damage during transit. Save the original packing material. If any indication of damage is found file a claim immediately with the responsible transport service.

3-3 For repairs of a product damaged in shipment, contact the Kepco Factory Representative nearest you or contact the Kepco Sales Department directly for further instruction.

3-4 INSTALLATION

3-5 The installation and set-up procedure for the TMA 488-27 consists of the following steps:
Set Device Address Selector.
Set Shield Ground Selector.
The preceding steps will allow the TMA488-27 to be connected on the IEEE 488 GPIB, (refer to Back Panel and Installation Drawings, FIG. 3-1 and FIG. 3-2 respectively).
Note: The TMA 488-27 can be powered from 95 to 264 Vac, no internal selection is required.

3-6 SET DEVICE ADDRESS AND SHIELD GROUND SELECTOR

3-7 The Device Address for the TMA 488-27 is initially set by means of DIP switches located on the rear panel. The Device Address is the permanent Listener or Talker address of the TMA 488-27 on the GPIB. It is factory preset to decimal 6. If a different Device Address is required in your system, proceed as follows, if not skip step 2. There are 31 (0-30) possible choices (See Table 3-1).

STEP 1: Place TMA 488-27 power module controller with the rear panel facing you. Between the RS 232 port, (J3) and the IEEE 488 port, (J4) there are 6 single pole switches. These switches are for the Device Address and Shield Ground Selector.

STEP 2: The Device Address Selector switches are the first 5 (from right to left). These switches are preset by Kepco to address 6. For other device addresses set them according to Table 3-1.

STEP 3: The extreme left switch is the Shield Ground Selector. In the ON position, the cable shield on the IEEE 488 bus is connected to common. In the OFF position, the bus shield is floating (not grounded to TMA 488-27 common).

3-8 INSTALLATION OF THE MODEL TMA 488-27 (Refer to FIG. 3-2)

3-9 The TMA 488-27 may be operated on a bench or it can be installed into a standard 19 inch equipment rack. The sides of the unit have inserts for chassis slide mounting. Chassis slides must be drilled according to the mounting hole pattern in FIG. 3-2. Spacers (9/16 in) are needed for mounting the slides, so as to avoid obstruction of the ventilation slots.

3-10 PREPARATION AND INSTALLATION OF THE KEPCO CABLE ASSEMBLIES

3-11 The maximum cable length for the Control Bus is 300 meters (1000 feet). The specifications on the cable are listed in Table 3-2.

3-12 FINAL SYSTEM INTERCONNECTIONS

3-13 Connect the TMA 488-27 to the GPIB or RS 232 bus, connect the Discrete Fault Line to the Host Computer, connect the TMA 488-27 to the Control Bus, and connect all the power modules to the Control Bus (see Section II, FIG. 2-2). All power module outputs should be connected to their respective loads. For MAT Power Module Calibration see the MAT Operator's Manual.

DECIMAL ADDRESS	A5	A4	A3	A2	A1
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
9	0	1	0	0	1
10	0	1	0	1	0
11	0	1	0	1	1
12	0	1	1	0	0
13	0	1	1	0	1
14	0	1	1	1	0
15	0	1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1
18	1	0	0	1	0
19	1	0	0	1	1
20	1	0	1	0	0
21	1	0	1	0	1
22	1	0	1	1	0
23	1	0	1	1	1
24	1	1	0	0	0
25	1	1	0	0	1
26	1	1	0	1	0
27	1	1	0	1	1
28	1	1	1	0	0
29	1	1	1	0	1
30	1	1	1	1	0

TABLE 3-1 DEVICE ADDRESS SELECTION FOR THE KEPCO MODEL TMA 488-27 POWER MODULE CONTROLLER

3-14 REAR TERMINATIONS ON THE TMA 488-27

A) The AC Input (J5) – The input connector J5 has a 2.5A, 250 Vac fuse (5.0 x 20 mm), Kepco P/N 141-0082. The power line connection is made via a removable 115 Vac power line cord, KEPCO P/N 118-0552, which is supplied with the unit. This cord is for use in the U.S. and Canada. For operation in other countries consult your Kepco Representative. The TMA 488-27 can be powered from an ac source within the range of 95 to 264V.

B) The Discrete Fault Port (J1) – This port is terminated with a miniature, 2 pin locking-type connector, KEPCO P/N 143-0313 (supplied). The function of the Discrete Fault Port is the same as the Line Status Monitor Port, described in Section IV, paragraph 4-50.

C) The IEEE 488 BUS (J4) – This port is terminated with a 24 pin IEEE 488 connector and conforms mechanically and electrically to the IEEE 488 standard.

NOTE : TMA 488-27 has a Shield Ground Selector on the IEEE 488 Interface board, providing the option of either grounding the shield externally or internally (refer to paragraph 3-7).

D) The RS 232 Port (J3) – This port is terminated with a standard 25 pin RS 232 (female) connector. The TMA 488-27 will communicate with a "dumb" terminal, in particular the following ones listed in Section IV, Table 4-1

E) The Control Bus (J2) – This port is terminated with a 5 pin DIN connector, KEPCO P/N 143-0355.

F) Control Bus Terminating Connector – The end of the Control Bus is terminated with a 5 pin DIN connector, Kepco P/N 195-0075.

SPECIFICATIONS FOR THE CONTROL BUS CABLE
1) Shield nominal dc resistance - 3.35 ohms per 1000 ft.
2) Nominal outer diameter - .252 in. (6.41mm)
3) Nominal impedance - 120 ohms
4) Nominal capacitance between conductors - 12.8 pF/ft. (41.7 pF/m)
5) Nominal capacitance between one conductor and other conductors connected to the shield 23 pF/ft. (75.65 pF/m)
GENERAL
A) Polyethylene insulated twisted pairs
B) Overall Beldfoil aluminum - polyester shield
C) Stranded tinned copper drain wire 24 AWG
D) Overall tinned copper braid shield (90% Coverage)

TABLE 3-2 SPECIFICATIONS FOR THE CONTROL BUS CONNECTING THE TMA 488-27 TO MAT POWER MODULES

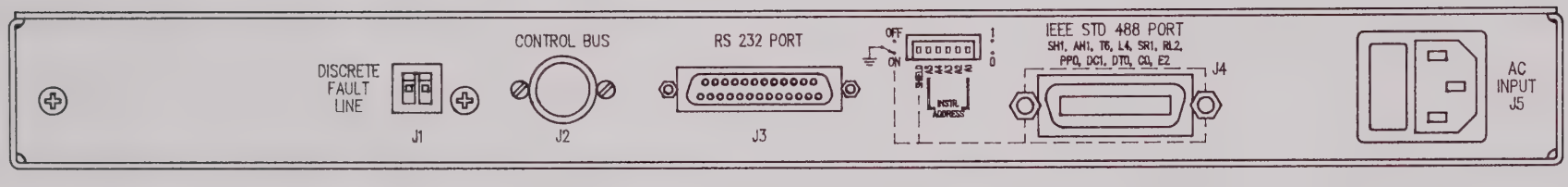


FIGURE 3-1 BACK PANEL OF THE TMA 488-27 POWER MODULE CONTROLLER

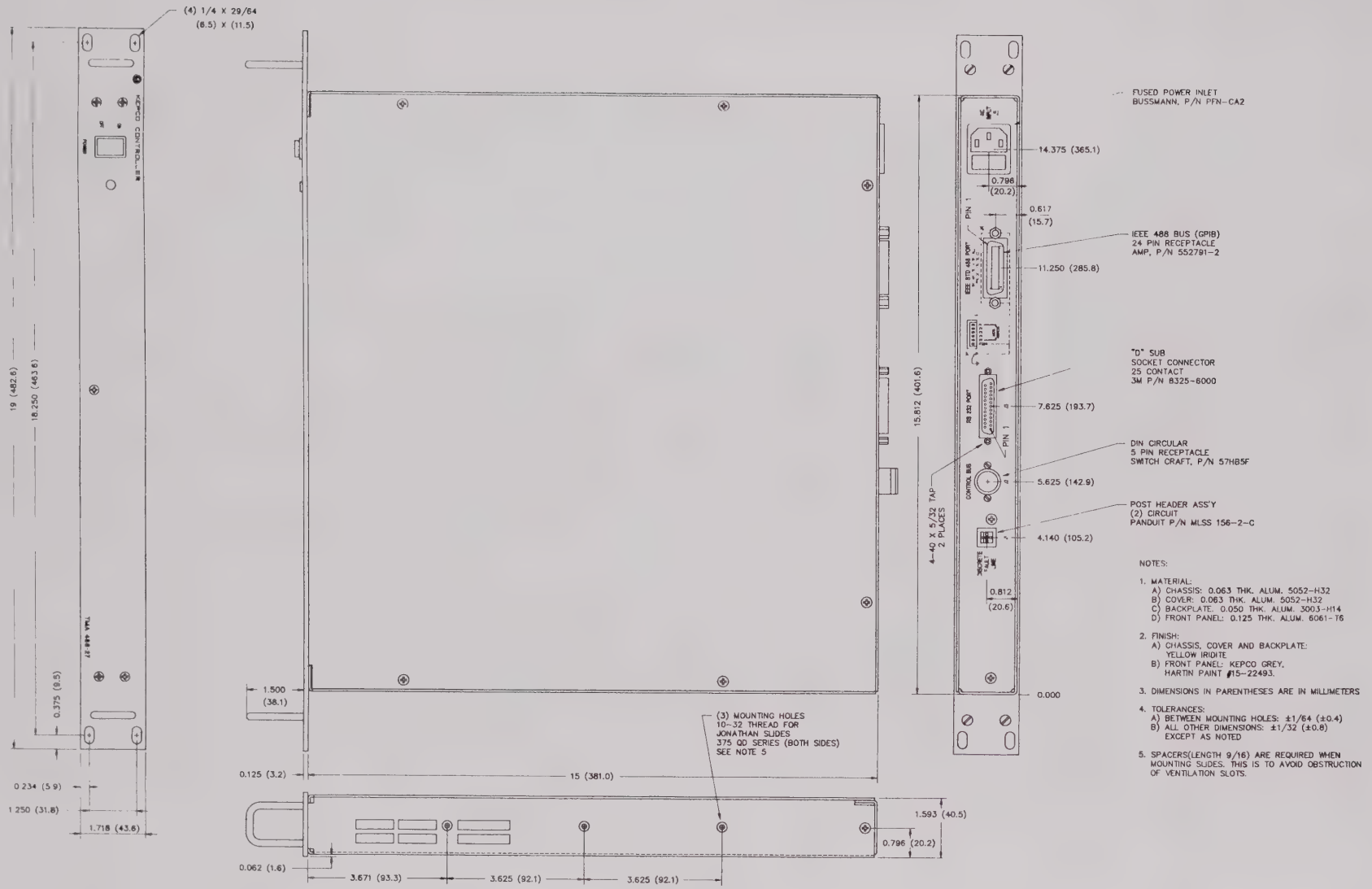


FIGURE 3-2 INSTALLATION DRAWINGS — MECHANICAL OUTLINES OF THE TMA 288-27 POWER MODULE CONTROLLER

SECTION IV - OPERATION

4-1 GENERAL

4-2 To establish successful operation of a digitally controlled power module system consisting of a Host Computer, a TMA 488-27 Power Module Controller, and a number of MAT power modules, the following guidelines must be adhered to:

1) Continuously monitor the Discrete Fault line.
2) Any command sent by the Host Computer to the TMA 488-27, which affects the outputs of the power modules or their relays, must be followed by a STA (Status) inquiry.
3) Request for status should be sent after the proper timeout, permitting the output of the power module and the relay to settle.
4) Whenever an error message is detected, the Host Computer must send repeated STA commands accompanied by an MTA (My Talk Address) until the condition normal message is received. If this is not done, subsequent STA commands will extract an unreported error message which may have occurred long before the present events.
5) If the response to a STA command is the error message NOT READY, the STA command should be repeated. Specific time delays depend on the particular MAT Power Module used, see MAT Operator's Manual.

4-3 Once the TMA 488-27 Interactive Programmer has been prepared and interconnected as described in Section III of this manual, operation can proceed. The TMA functions as a Talker/Listener on the General Purpose Interface Bus (GPIB is defined by ANSI/IEEE Standards 488.1-1987 which includes IEC625-1). The GPIB Controller (Host Computer) will communicate with the TMA via the GPIB, using the specified IEEE 488 protocol as well as elements of the Control Interface Intermediate Language (CIIL). Since the TMA can accommodate from one (1) to twenty seven (27) programmable power modules, up to and including twenty seven power modules can be digitally programmed via the GPIB. The Host Computer may be programmed to implement the Modular Automatic Test Equipment (MATE) protocol, while fulfilling MATE Test Module Adapter requirements. The Host may be programmed for non-MATE applications, and should have the capability to implement the Service Request and Serial-Poll messages. The RS 232 serial communications port can be used instead of the IEEE 488 parallel port to communicate with a terminal. For details on RS 232 communications see paragraph 4-7.

4-4 COMMUNICATIONS

4-5 TMA to MAT communications take place on the Control Bus, a 2 wire serial bus. The Control Bus runs at 375K baud. The Bus is Half Duplex, Multidrop, with the TMA acting as Bus Master.

4-6 TMA to Host Computer communications can take place over the IEEE 488 interface board, (J4) or the RS 232 interface board, (J3).

4-7 Communications from a terminal to the TMA 488-27, using the RS 232 (EIA 232) interface, are provided for with nine (9) possible choices for terminal selection see Table 4-1.
The ninth choice notes a terminal not listed in the previous eight choices.
All commands work the same way as on the IEEE 488 GPIB with the following deviations.

A) There is no IEEE GPIB protocol function DCL (Device Clear) equivalent in RS 232. The function exits as a command not part of the RS 232 bus porotocol. The Device Clear Command is DCL.
B) There is no IEEE GPIB protocol function RL2 (Remote Local) equivalent in RS 232. The functions exists as two separate software implemented commands not part of the RS 232 bus protocol. The two commands are REN (Remote Enable) and GTL (Go To Local).

TERMINALS FOR THE TMA 488-27 POWER MODULE CONTROLLER	
1) Hazeltine 1510	5) Adds Viewpoint 3a Plus
2) Lear Siegler Adm3a	6) Dec VT100, VT101, VT102 or ANSI Terminal
3) Qume QVt102	7) Dec VT52
4) Televideo 910 Plus, 925 or 950	8) Zentec Zepher or Cobra
	9) Default (none of the above)

TABLE 4-1 COMPUTER TERMINALS AVAILABLE FOR COMMUNICATIONS WITH THE TMA 488-27 VIA THE RS 232 SERIAL COMMUNICATIONS BUS

When the terminal is started it is in local mode, and there are no commands or messages. REN allows communications, while GTL inhibits communications. The other exception to the rule of GTL preventing communications between the TMA and the computer terminal is, when the TMA has been enabled and then disabled. The disable state resulting from a Power Loss, Overtemperature, or a Crowbar error. These errors will appear as they occur, regardless of what state of communications exist between TMA and the computer terminal (REN or GTL).

C) For every command that is sent over the RS 232 bus a status response of the system is returned.

D) The alternate language commands, S0 through S3 are not implemented, when RS 232 communications are used. For details on these commands see paragraph 4-31

4-8 Communications between the TMA 488-27 Talker/Listener and the Host Computer -- Controller/Talker/Listener, implements the interface functions listed in Table 4-2.

GPIB FUNCTION	SUBSET SYMBOL	COMMENTS
Source Handshake	SH1	Complete Capability
Acceptor Handshake	AH1	Complete Capability
Talker	T6	Basic talker, serial poll,unaddress if MLA
Listener	L4	Basic Listener,unaddress if MTA
Service Request	SR1	Complete Capability
Remote Local	RL2	No local lock-out
Parallel Poll	PP0	No Capability
Device Clear	DC1	Complete Capability
Device Trigger	DT0	No Capability
Controller	C0	No Capability

TABLE 4-2 IEEE 488 INTERFACE FUNCTIONS IMPLEMENTED BY TMA 488-27

A) In Command Mode, the TMA 488-27 will send or receive remote messages per IEEE 488 protocol as listed in Table 4-3.

MNEMONIC	MESSAGE DESCRIPTION	COMMENTS
ATN	Attention	Received
DAC	Data Accepted	Received or Sent
DAV	Data Valid	Received or Sent
DCL	Device Clear	Received
IFC	Interface Clear	Received
MLA	My Listen Address	Received
MTA	My Talk Address	Received
OTA	Other Talk Address	Received
RFD	Ready for Data	Received or Sent
SDC	Selected Device Clear	Received
SPD	Serial Poll Disable	Received
SPE	Serial Poll Enable	Received
SRQ	Service Request	Sent
UNL	Unlisten	Received
UNT	Untalk	Received

TABLE 4-3 MESSAGES SENT OR RECEIVED BY THE TMA 488-27 IN COMMAND MODE

B) In Data Mode, the TMA 488-27 will send or receive remote messages per IEEE 488 protocol as listed in Table 4-4. These messages are enabled during the "handshake" cycle, with the TMA 488-27 operating as a Talker or as a Listener.

MNEMONIC	MESSAGE DESCRIPTION	COMMENTS
DAB	Data Byte	Received or Sent
END	End	Received or Sent
EOS	End of String (line feed)	Received or Sent
RQS	Request Service	Sent
STB	Status Byte	Sent

TABLE 4-4 MESSAGES SENT OR RECEIVED BY THE TMA 488-27 IN DATA MODE

4-9 CIIL CODES

4-10 All other communications on the GPIB in Data Mode are not defined by IEEE 488 Standard. Instead, the syntax and mnemonics of the Control Interface Intermediate Language (CIIL) are used to program and test the power modules, report their status, and send error messages. The CIIL elements used for this purpose are the Operation Codes, Nouns, and Noun Modifiers listed below and discussed in detail in the following paragraphs.

CIIL is a subset of ATLAS. For special or non-MATE requirements some non-CIIL commands are accepted in the alternate language see paragraph 4-29.

A) CIIL OPERATION CODES (OP CODES):

FNC -- FUNCTION
SET -- SET
SRX -- SET MAXIMUM
SRN -- SET MINIMUM
INX -- INITIATE
FTH -- FETCH
CLS -- CLOSE
OPN -- OPEN
IST --- INTERNAL SELF TEST
CNF -- CONFIDENCE TEST
RST __ RESET
STA -- STATUS
GAL -- GO TO ALTERNATE LANGUAGE

B) NOUNS:

DCS __ DIRECT CURRENT SOURCE

C) NOUN MODIFIERS:

VOLT ---VOLTAGE MODE OPERATION
VLTL----VOLTAGE LIMIT
CURR ---CURRENT MODE OPERATION
CURL ---CURRENT LIMIT

D) Delimiters: All Op Codes and Operands must be separated by the ASCII "space" code (ASCII Value 32 [SP])

E) Terminators: The MATE (Modular Automatic Test Equipment) protocol requires that all command strings are terminated by a "carriage return" and "line feed" (ASCII Values 13 (cr), 10 (lf) respectively). Alternately, for non-MATE applications, the END message (see Table 4-4) may be used as a terminator. The TMA 488-27 sends both, a "line feed" (lf) and the END command when messages are sent. It accepts both, "line feed" (lf) or the END command as terminators when receiving messages.

F) The required delay times following a command are dependent on the specific MAT Power Module being used (see MAT Operator's Manual for details).

4-11 THE FUNCTION COMMAND

4-12 FNC - Function Op Code – This operator is uniquely associated with the start of a set-up sequence for the device. There are two (2) operand fields associated with this op code.

SYNTAX: FNC DCS :CHnn

OP CODE, DELIMITER, OPERAND1, DELIMITER, OPERAND2

NOTE: This is an incomplete command. Complete FNC commands are followed by a SET command and terminated with the ASCII characters (cr) and (lf). That is unless the FNC command is used in conjunction with the INX and FTH command sequence. In that case the command requires the termination characters (cr) and (lf).

A) The Function Command is always the first command in the set-up sequence.

B) The first operand field of the command contains the three (3) letter mnemonic pertaining to the device on the GPIB. For the Kepco Model TMA 488-27 it is "DCS" (Direct Current Source).

NOTE: An ASCII "space" (SP), ASCII 32 is used as a Delimiter between Op Code and Operand and between Operands.

C) The second operand field of the command is used to select the specific input "Port" of the device being programmed. The Kepco Model TMA 488-27 has twenty seven (27) possible power modules connected to it and these MAT power modules have an address range of 1 to 30. The second Operand is a one or two digit ASCII integer (1 to 30), designating the power module channel being programmed at the time of command execution.

4-13 THE SET, SRX and SRN COMMANDS

4-14 SET - Set Op Code – This operator is used to specify the output mode of the power module being programmed. The Noun Modifier is the first operand and the second operand specifies the value in ASCII characters.

SYNTAX: SET VOLT value

OP CODE, DELIMITER, OPERAND1, DELIMITER, OPERAND2

NOTE: This is an incomplete command. Complete Commands are preceded by FNC command and terminated with the ASCII characters (cr) and (lf).

A) The first operand field of the command contains the four (4) letter mnemonic for the output mode of the Power Module. The choices are:

VOLT ---- VOLTAGE MODE OPERATION
VLTL ---- VOLTAGE LIMIT
CURR ---- CURRENT MODE OPERATION
CURL ---- CURRENT LIMIT

B) The second operand field of the command contains the value assigned to the chosen output mode. This value may be specified as accurately as the resolution of the MAT power module allows (12 bits, or .024% of maximum rated voltage or current). It can be specified directly in ASCII integer, decimal or in scientific notation.

NOTE: There are two (2) SET commands, separated by the ASCII (SP) delimiter, for each power module being programmed. The following combinations are the only legal combinations.
VOLT with CURL
CURR with VLTL

NOTE: To readjust the setting of the limit quantity (VLTL or CURL), a complete command **MUST** be sent which includes the value of the principal mode (VOLT or CURR). Otherwise, an "INVALID COMMAND" would ensue.

C) For both unipolar power supplies and bipolar power supplies, polarity signs (+ or -) preceding the voltage or current values in operand 2 determine the polarity of their output terminal with reference to their common terminal.

D) In addition to the SET command, two (2) related Op Codes SRX and SRN are functionally identical to the SET command:

1) SRX ----- Set Maximum
2) SRN ---- Set Minimum

The format of the command sequence is identical to that used for the SET command, with SRX and SRN replacing SET in the syntax. The power modules (stimulus) will see these commands with the ensuing priority in descending order:

1) SET 2) SRN 3) SRX
highest lowest

As a sensor (meter) the priority of the commands is, in descending order:

1)SRX 2) SET 3)SRN
highest lowest

4-15 THE OPEN/CLOSE RELAY COMMANDS

4-16 The relays located in the MAT modules connect the output terminals of each of the power modules to their associated loads. The TMA 488-27 commands to the relays are as follows:
SYNTAX: OPN :CHnn(cr)(lf)
OP CODE, DELIMITER, OPERAND1, TERMINATORS

NOTE: All complete commands are terminated with the ASCII characters (cr) "carriage return" and (lf) "line feed".

A) OPN - Open Op Code – This operator is used to open the power module relay specified by the Operand. Only a single Operand is used with this Op Code. It is identical in format and meaning to the port identification field of the FNC command.

B) CLS - Close Op Code –This operator is analogous to the OPN Op Code, however with the Close Op Code the TMA 488-27 will close the power module relay specified by the Operand.

4-17 THE RESET COMMAND

4-18 RST - Reset Op Code. This operator is used to program the addressed power supply output to zero and open the relay associated with it.
SYNTAX: RST DCS :CHnn(cr)(lf)
OP CODE, DELIMITER, OPERAND1, DELIMITER, OPERAND2, TERMINATORS
The RST command has the same operand fields as the FNC command.

4-19 THE CONFIDENCE TEST COMMAND

4-20 CNF - Confidence Test Command – This operator commands the TMA 488-27 to execute the confidence test procedure defined for the TMA/MAT power modules. As a result of the CNF command, all isolation relays are opened and an internal localized test is performed. This test ascertains if all the function blocks of the control section (microcomputer) are working properly. Also the CNF command programs all power modules connected on the Control Bus to go to their maximum ratings and checks for the error flags. Upon completion of the test, all relays remain open, while the power modules are programmed to zero.
SYNTAX: CNF(cr)(lf)
OP CODE,TERMINATORS
No operands are associated with this Op Code. The result of the Confidence Test is reported in response to a status (STA) command. The STA command should be issued only after the required delay time is observed.

4-21 INTERNAL SELF TEST COMMAND

4-22 IST - Internal Self Test Command. This command evokes the identical response as the CNF command. This is because the TMA 488-27 is not designed to support an internal self-test (BIT).

4-23 STATUS COMMAND

4-24 STA - Status Request Op Code – This operator commands the TMA 488-27 to report its current operating status.

SYNTAX: STA(cr)(lf)
OP CODE,TERMINATORS
No operands are associated with this op code. The response for the Status Request is in accordance with the Response Message Syntax described in paragraphs 4-42 through 4-48. It is important to impose the proper time delays (specific time delays depend on the particular MAT Power Module used, see MAT Operator's Manual) before the Status Command is issued. The TMA 488-27 responds to the STA command as soon as it is Talk Addressed by the Host Computer (Controller). If conditions are normal, only one response message is sent. If conditions are abnormal, the controller should send multiple Status Commands and Talk Addresses to the TMA 488-27 until all error messages are collected and transmitted (see paragraph 4-45)

4-25 INITIATE COMMAND

4-26 INX - Initiate Op Code –Commences data acquisition or analysis process in accordance with the preceding FNC command (paragraph 4-12). When the Initiate (INX) is performed, the required delay time (specific time delays depend on the particular MAT Power Module used, see MAT Operator's Manual) is sent back to the Host Computer. The INX command does not transmit the data to the Host Computer, transmission is done with the Fetch Command.
In the event a catastrophic error occurs the error message (see paragraphs 4-46 to 4-53) will be sent in lieu of the delay time.

SYNTAX: INX VOLT(cr)(lf)
OP CODE, DELIMITER, OPERAND1, TERMINATORS
Operand 1 selects the measured parameter. Two (2) operands are valid, they are VOLT for voltage and CURR for current.

4-27 FETCH COMMAND

4-28 FTH - Fetch Op Code – Used to instruct the previously designated power module to send the acquired data. The data was acquired according to the preceding INX (paragraph 4-26).

NOTE: If FTH is sent before time out has occurred, the error message NOT READY will be sent and the process will be aborted.

SYNTAX: FTH VOLT(cr)(lf)
OP CODE, DELIMITER, OPERAND1, TERMINATORS
Operand 1 selects the measured parameter. Two (2) operands are valid, they are VOLT for voltage and CURR for current.

4-29 GO TO ALTERNATE LANGUAGE COMMAND

4-30 GAL - Go To Alternate Language Op Code. When the GAL command is sent the Host Computer will access non-CIIL commands, see paragraph 4-31 and the ensuing eight paragraphs.
SYNTAX: GAL(cr)(lf)
OP CODE,TERMINATORS
No operands are associated with this op code.

4-31 The subsequent non-CIIL commands are defined for the TMA 488-27. They are: S0, S1, S2, S3, R0, R1, T0, T1, and CIIL. Their functions are:

T0 - Erase Error Message
T1 - Do Not Erase Error Message
S0 - Disable Service Request
S1 - Enable Service Request (1)
S2 - Enable Service Request (2)
S3 - Clear Serial Poll
R0 - Do Not Report Relay Error

R1 - Report Relay Error
CIIL - Return to CIIL

4-32 **ERROR HANDLING COMMANDS (T0 and T1)**

4-33 **T0** - Erase Error Message Op Code – This operator commands the TMA 488-27 to erase previously recorded, but unreported noncatastrophic error messages from the buffer as soon as a new valid command is received or a catastrophic error occurs. This is the default state after power on.

T1 - Do Not Erase Error Message Op Code. This operator commands the TMA 488-27 not to erase previously recorded but unreported error messages from the error buffer. In order to gather all error messages, multiple STA commands and Talk Addresses should be sent by the controller. The error buffer is clear of error messages if the response for the STA is a "normal" response (i.e. (sp)(cr)(lf)).

SYNTAX: T0(cr)(lf) SYNTAX: T1(cr)(lf)
OP CODE,TERMINATORS OP CODE,TERMINATORS

4-34 **SERVICE REQUEST and SERIAL POLL COMMANDS (S0,S1,S2,S3)**

4-35 **S0** - Disable Service Request Op Code –This command disables the IEEE 488 Service Request line. This command is default at power on.

SYNTAX: S0(cr)(lf)
OP CODE,TERMINATORS

STATUS BYTE CONFIGURATION

BIT NUMBER	BIT DESCRIPTION
1	Address Code Of The Channel (1 To 30) That Flagged The Fault Condition
2	
3	
4	
5	
6	Catastrophic Error
7	RQS Message
8	Noncatastrophic Error

FIGURE 4-1 THE STATUS BYTE REGISTER FOR ALL DEVICES ON THE IEEE 488 GPIB IS SERIALLY INTERROGATED TO CHECK BIT 7

S1 - Enable Service Request (1) Op Code – Used to enable the Service Request line of the IEEE 488 GPIB. This will allow the TMA 488-27 to notify the Host Computer only in the event of catastrophic errors. No operands are associated with this op code.

S2 - Enable Service Request (2) Op Code – Used to enable the Service Request line of the IEEE 488 GPIB. This will allow the TMA 488-27 to notify the Host Computer if catastrophic and noncatastrophic errors occur. No operands are associated with this op code.

S3 - Clear Serial Poll Op Code. This command S3 will clear the RQS bit of the Status Byte (bit 7), see FIG. 4-1. No operands are associated with this op code.

4-36 **RELAY ERROR COMMANDS (R0 and R1)**

4-37 **R0** - Relay Error Not Reported Op Code – This operator will disable the relay error messages, so that no relay error messages will be reported by the TMA 488-27. No operands are associated with this op code.

R1 - Relay Error Reported Op Code —This operator will enable the TMA 488-27 to notify the Host Computer in the event that a relay error has occurred. No operands are associated with this op code. This command is default at power up.

4-38 **RETURN to CIIL COMMAND**

4-39 CIIL - Return to CIIL Op Code – This command will allow the Host Computer to again call up CIIL commands. This op code has no operands associated with it.
SYNTAX: CIIL(cr)(lf)
OP CODE,TERMINATORS

4-40 **BUS TRANSMISSION FORMAT**

4-41 The CIIL transmission format for a single power module is given below. As an example, to program a power module with a channel address of 3, as a voltage source of 6 volts with a current limit setting of 10.5 amps, the following string of ASCII encoded characters must be sent by the Host Computer.

HOST COMPUTER MESSAGE	TMA/MAT RESPONSE
FNC DCS :CH3 SET VOLT 6 SET CURL 10.5 (cr) (lf)	
To check the Status after the delay time, send: STA (cr) (lf) [Input String]	 (sp) (cr) (lf)
To close the relay and enable the output at the load send: CLS :CH3 (cr) (lf)	
To check the closing of the relay send STA (cr) (lf) [Input String]	 (sp) (cr) (lf)
To measure the output voltage send: FNC DCS VOLT :CH3 (cr) (lf) INX VOLT (cr) (lf) [Input String] FTH VOLT (cr) lf) [Input String]	 00 (cr) (lf) 6.0000E0 (cr) (lf)
To measure the output current send: FNC DCS CURR :CH3 (cr) (lf) INX CURR(cr) (lf) [Input String] FTH CURR (cr) lf) [Input String]	 00 (cr) (lf) 8.5413E0 (cr) (lf)
To program output to zero and disable the output send: RST DCS :CH3 (cr) (lf)	
To check Status after reset send: STA (cr) (lf) [Input String]	 (sp) (cr) (lf)

NOTES:

A) [Input String] implements the Host Computer Interface Board specifics including any necessary IEEE 488 GPIB commands

B) To readjust the setting of the limit quantity (VLTL or CURL), a complete command **MUST** be sent which includes the value of the principal mode (VOLT or CURR). Otherwise, an "INVALID COMMAND" would ensue.

4-42 RESPONSE MESSAGE SYNTAX

4-43 The Controller or Test Executive (Host Computer), requests the present operating Status (via STA and the Talk Address) of the TMA 488-27. To obtain a meaningful response, the controller should use the STA (Status) command only after waiting the proper time delay. The response of the TMA 488-27 to a STA command is sent to the Host Computer (controller) in the form described below. The status is either reported as "normal" or as "abnormal". If conditions are normal, only one response message is sent. That is unless INX is received, and no abnormal conditions exist, in that case the current time-out value (specific time delays depend on the particular MAT Power Module used, see MAT Operator's Manual) is sent. If conditions are abnormal, the controller (Test Executive) should send multiple status commands and Talk Addresses to the TMA 488-27 until all error messages are collected and transmitted.

4-44 Condition NORMAL – All "normal" response messages begin with an ASCII (32) space, followed by a carriage return ASCII (13) and a line feed ASCII (10):
SYNTAX:(sp)(cr)(lf)
Exception, if response is a delay time then the Value (ASCII integer code) is the delay time in seconds followed by a carriage return ASCII (13) and a line feed ASCII (10):
SYNTAX: (sp)Value(cr)(lf)

4-45 Condition ABNORMAL – All "abnormal" response messages begin with the ASCII "F " (70), followed by a 2 digit ASCII integer code, followed by a text string describing the error condition. The 2 digit code used for TMA 488-27 by the controller (Host Computer) to take corrective action is 07 (HALT).
SYNTAX: F07DCSnn (bbb): Text (cr) (lf)

4-46 The subsequent list includes error messages transmitted over the GPIB, in response to either the STA, INX or the FTH commands, when an error condition is detected and the TMA is "Talk Addressed". The error conditions marked with an * also activate the Discrete Fault line.

A) POWER SUPPLY RELATED ERROR MESSAGES:

1) F07DCSnn (DEV): CROWBARRED (unipolar supply)*
2) F07DCSnn (DEV): DEVICE TURNED OFF (bipolar supply)*
3) F07DCSnn (DEV): OVERLOAD *
4) F07DCSnn (DEV): VOLTAGE COMPARISON ERROR *
5) F07DCSnn (DEV): CURRENT COMPARISON ERROR *
6) F07DCSnn (DEV): RELAY NOT OPEN *
7) F07DCSnn (DEV): RELAY NOT CLOSED *
8) F07DCSnn (DEV): DEVICE NOT PRESENT
9) F07DCSnn (DEV): INVALID DEVICE ID
10) F07DCSnn (DEV): VOLTAGE OUT OF RANGE
11) F07DCSnn (DEV): CURRENT OUT OF RANGE
12) F07DCSnn (DEV): SET MODIFIER ERROR
13) F07DCSnn (DEV): POLARITY ERROR *
14) F07DCSnn (DEV): OVERTEMPERATURE *
15) F07DCSnn (DEV): POWER LOSS *
16) F07DCSnn (DEV): DEVICE NOT RESPONDING
17) F07DCSnn (DEV): NOT READY

B) SYSTEM RELATED ERROR MESSAGES:

1) F07DCSnn (MOD): INVALID COMMAND

2) F07DCSnn (MOD): RECEIVED INCOMPLETE MESSAGE

NOTES:

1) nn: Channel number
2) Error conditions marked with an asterisk will initiate "SRQ" on the IEEE GPIB.
3) All error messages are terminated with an ASCII (cr) (lf).
4) "INVALID COMMAND" error message is transmitted when one of the following error conditions are detected.
   a) unrecognizable op code
   b) unrecognizable noun
   c) unrecognizable noun modifier
   d) incomplete command string
   e) syntax error

4-47 If multiple errors occur on a connected power module as a result of a fault condition, only the messages with the highest priority will be sent to the TMA 488-27 error message buffer. The priority of the error messages are as follows (in descending order)

1) OVERTEMPERATURE (highest)
2) CROWBARRED / DEVICE TURNED OFF
3) POWER LOSS
4) RELAY NOT (OPEN /CLOSED)
5) OVERLOAD
6) POLARITY ERROR
7) (VOLTAGE / CURRENT) COMPARISON ERROR (lowest)

4-48 The abnormal response syntax is used by the TMA 488-27 whenever a detected error condition has not yet been reported to the Host Computer (controller). Such errors are reported whenever the TMA 488-27 has been "Talk Addressed" per GPIB protocol. Once a particular condition has been reported to the Host Computer it will continue to be reported until the error condition is removed.

4-49 CATASTROPHIC ERROR HANDLING

4-50 Non-critical error conditions may invalidate certain test results, but will not cause a condition which is hazardous to either the station operator, station instrumentation or the unit under test (UUT). Those error conditions which might prove hazardous, are additionally flagged by the Discrete Fault Line.

4-51 The Discrete Fault Line (Status Monitor Output) consists of a contact pair, terminated at the rear of the TMA 488-27 (J1). A two wire connection may be returned to the controller. Any error condition, as listed in the preceding Power Supply Error Message Table and marked with an asterisk (*) will produce a contact closure on the Discrete Fault Line. Under normal conditions, the Discrete Fault Line is open.

4-52 MATE SYSTEM APPLICATIONS – Once the Status Monitor Line is activated, indicating the report of a catastrophic failure, the Host Computer responds by sending IFC (Interface Clear) and DCL (Device Clear) commands to the TMA 488-27, which places all the power modules connected on the Control bus, into an "idle" state (similar to Power on). Then the Host Computer sends The STA command and a Talk Address to the TMA 488-27 interrogating the error buffer, to find out which power module generated the fault condition and what nature the fault is, so that appropriate action can be taken. The Discrete Fault Lines will not be released until the TMA 488-27 error buffer has been cleared of all catastrophic error messages. To that

end, the Host Computer must send repeated STA commands, accompanied by the Talk Address until the Condition Normal message is received.

4-53 NON-MATE SYSTEM APPLICATIONS – An identical scenario as described for MATE systems may be used here for error handling. In place of the Discrete Fault Line, the Service Request and Serial Poll messages of the IEEE 488 bus may be used for non-MATE applications. Once the SRQ line (See paragraph 4-34) is activated, the subsequent Serial Poll command places all devices into the Serial Poll mode. The Status Byte register for all devices on the GPIB is serially interrogated for the status of bit 7. If the Request Service Status (RQS) on the TMA 488-27 is "true", bits 1 to 5 are queried for the channel address (1 -30) and bits six (6) and eight (8) tell if the error was catastrophic or noncatastrophic (see FIG. 4-1).

NOTE: If the Serial Poll reveals the existence of errors the STA command and Talk Addresses should be sent to extract the error messages from the TMA 488-27 Status Byte register until a "normal" response is received. If this is not done later STA commands may result in erroneous error messages.

4-54 GENERAL PROGRAMMING COMMENTS

4-55 The power module programming system consisting of a controller (Host Computer), The TMA 488-27 Interactive Programmer, and a number of power modules can be digitally programmed. Successful system operation is based on the principle of intercommunications between the system components. Intercommunications, in the context of the programming system under discussion, consists of the command sequence, the verification request issued by the controller, and the response from the TMA as to the status of each power module to be programmed. In practical terms, any command sent by the controller to the TMA 488-27 to affect the connected power modules or their relays, should be followed by an inquiry (status) request. The command and status inquiry from the controller must be separated by the proper delays.

4-56 In order to establish successful intercommunications between the Host Computer and the TMA 488-27 the following guidelines should be adhered to.

Following any command from the controller via the TMA 488-27 to the power modules or their relays, the status command (STA) and the Talk Address must be sent by the controller to verify the previous command(s). The TMA 488-27 will respond to the controller either with a Condition Normal, or a Condition Abnormal message. The syntax of the response messages is defined in paragraphs 4-42 through 4-48.

4-57 SAMPLE BASIC PROGRAM

4-58 The syntax and mnemonics of CIIL, can be used with high level computer languages to control and supervise the Kepco TMA/MAT system. In the following program the TMA 488-27 can control up to a maximum of 27 MAT power modules. The program requires an IBM PC or equivalent to be used with a Capital Equipment Corporation IEEE 488 Interface Card. Any PC or IEEE 488 Interface Card may be used, however modifications to the program may be necessary. This simple program will allow the Host Computer operator to set the MAT power modules for desired voltage or current values, close and open relays, and to read MAT power modules voltage or current measured parameters. The program can also reset the power modules. To assist in program comprehension a flow diagram of the program is included (see FIG. 4-2).

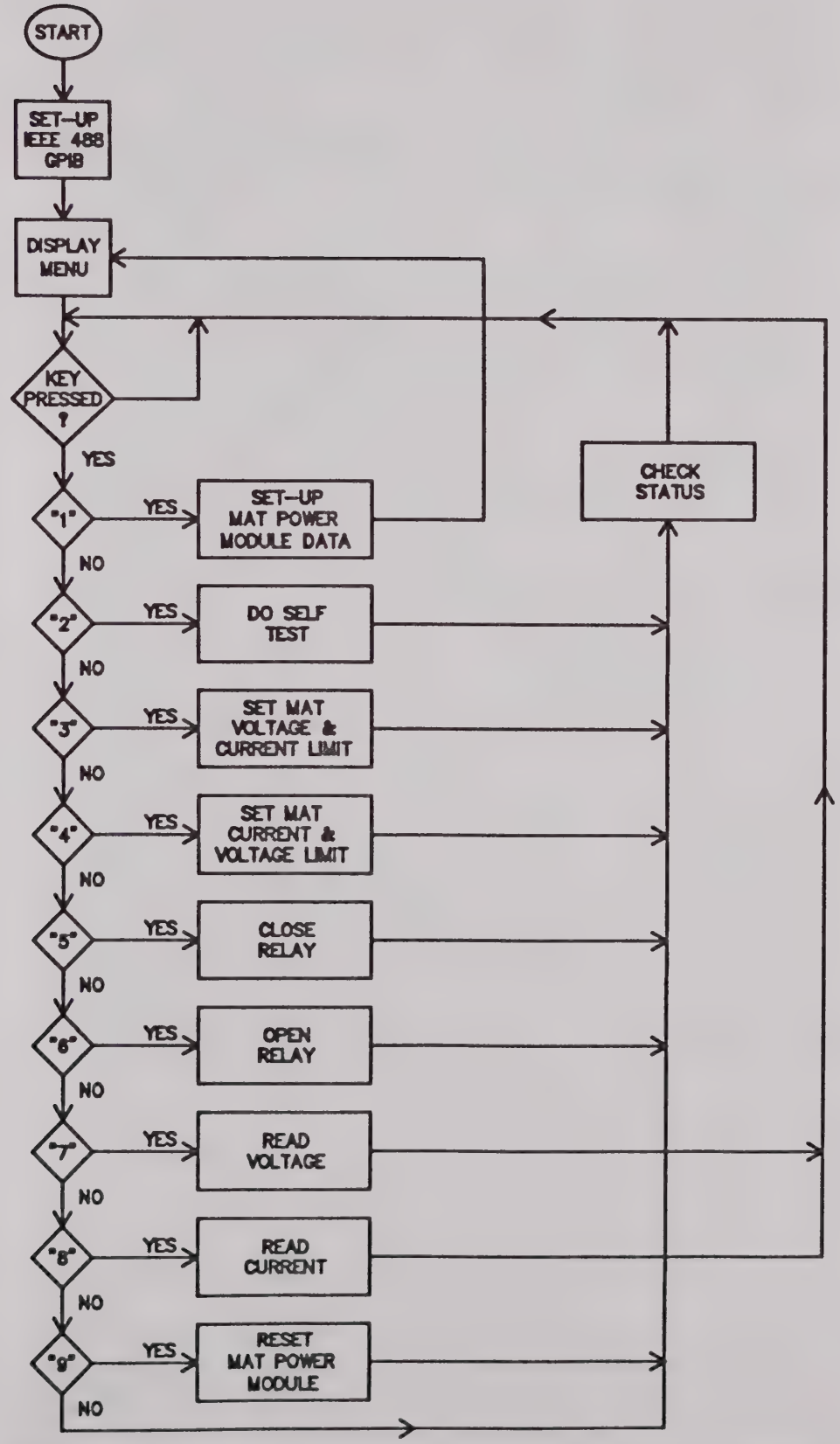


FIGURE 4-2 FLOW DIAGRAM OF THE SAMPLE BASIC PROGRAM FOR THE TMA 488-27/ MAT SYSTEM

```
10 '*************************************************************************
20 '***** SAMPLE PROGRAM FOR IBM PC. PROGRAM SYNTAX MAY VARY , DEPENDING  ******
30 '***** ON IEEE488 INTERFACE USED. THE SYNTAX USED IN THIS EXAMPLE IS   ******
40 '***** FOR THE CAPITAL EQUIP. CORP. MODEL 01000 IEEE488 INTERFACE.     ******
50 '*************************************************************************
100 DEF SEG = &HC000                              'memory location of interface
110 LEVEL% = 0 :ADDR% = 21                        'interface mode , address
120 INIT%= 0 :TRANSMIT%=3 :RECEIVE%= 6            'call addresses
130 CALL INIT%(ADDR%, LEVEL%)                     'initialize IEEE bus
140 REN$="REN":CALL TRANSMIT%(REN$,STATUS%)       'remote enable
150 LT$="MTA LISTEN 6 DATA '"                     'my talk address,listen address 6
160 DL$="'13 10 UNL"                              'carriage return line feed unlisten
190 '********************  MAIN ***************************************************
200 CLS :GOSUB 500                                          'display menu
210 G$=INKEY$:IF G$="" THEN 210                             'get key
220 ON VAL(G$) GOSUB 230,240,250,260,270,280,300,400,290    'do function
225 IF G$="7" OR G$="8" THEN 210 ELSE GOSUB 600 :GOTO 210   'read status
230 CLS :INPUT "CHANNEL";CH$:INPUT "VOLTAGE";V$ :INPUT "CURRENT";I$ :RETURN 200
240 DAT$="CNF" :GOSUB 700 :RETURN                           'self test
250 DAT$="FNC DCS :CH"+CH$+" SET VOLT " +V$ +" SET CURL " +I$ :GOSUB 700 :RETURN
260 DAT$="FNC DCS :CH"+CH$+" SET CURR " +I$ +" SET VLTL " +V$ :GOSUB 700 :RETURN
270 DAT$="CLS :CH"+CH$ :GOSUB 700 :RETURN                   'close relay
280 DAT$="OPN :CH"+CH$ :GOSUB 700 :RETURN                   'open relay
290 DAT$="RST DCS :CH"+CH$ :GOSUB 700 :RETURN               'reset
300 DAT$="FNC DCS VOLT :CH"+CH$ :GOSUB 700                  'read voltage
310 DAT$="INX VOLT"  :GOSUB 700 :GOSUB 670
320 LOCATE 12,1:PRINT SPACE$(79) :LOCATE 12,1:PRINT "TIMEOUT : "REC$
330 IF VAL(REC$) THEN 300 ELSE DAT$="FTH VOLT" :GOSUB 700 :GOSUB 670
340 LOCATE 12,1:PRINT SPACE$(79) :LOCATE 12,1:PRINT "VOLTAGE : "REC$ :RETURN
400 DAT$="FNC DCS CURR :CH"+CH$ :GOSUB 700                  'read current
410 DAT$="INX CURR" :GOSUB 700 :GOSUB 670
420 LOCATE 14,1:PRINT SPACE$(79) :LOCATE 14,1:PRINT "TIMEOUT : "REC$
430 IF VAL(REC$) THEN 400 ELSE DAT$="FTH CURR" :GOSUB 700 :GOSUB 670
440 LOCATE 14,1:PRINT SPACE$(79) :LOCATE 14,1:PRINT "CURRENT : "REC$ :RETURN
500 '************************ CIIL MENU  ***************************************
510 PRINT "1) ENTER DATA                  2) PERFORM SELF TEST          "
520 PRINT "3) SET VOLTAGE MODE            4) SET CURRENT MODE           "
530 PRINT "5) CLOSE ISOLATION RELAY       6) OPEN ISOLATION RELAY       "
540 PRINT "7) READ VOLTAGE                8) READ CURRENT               "
550 PRINT "9) RESET POWER SUPPLY          0) CHECK STATUS               " :PRINT
560 PRINT "ENTER THE NUMBER FOR THE FUNCTION YOU WANT                   " :PRINT
570 PRINT "CURRENT COMMAND :                                            "
580 PRINT "CURRENT STATUS  :                                            " :RETURN
600 '********************* CHECK STATUS ****************************************
610 ST$=LT$+"STA"+DL$                                       'string to send
620 CALL TRANSMIT%(ST$,STATUS%) :GOSUB 670                  'transmit STA
630 LOCATE 10,20 :PRINT SPACE$(50)                          'clear line
640 LOCATE 12,1  :PRINT SPACE$(50)                          'clear line
650 LOCATE 14,1  :PRINT SPACE$(50)                          'clear line
660 LOCATE 10,20 :PRINT REC$ :RETURN                        'print status
670 TK$="TALK 6" :CALL TRANSMIT%(TK$,STATUS%)               'talk address
680 REC$ = SPACE$(50)                                       'allocate space
690 CALL RECEIVE%(REC$, LENGTH%, STATUS%) :RETURN           'receive string
700 '********************* TRANSMIT DATA ***************************************
710 TR$= LT$ + DAT$ + DL$                                   'string to be sent
720 CALL TRANSMIT%(TR$,STATUS%)                             'send string
730 LOCATE 9,20 :PRINT SPACE$(60)                           'clear line
740 LOCATE 9,20 :PRINT DAT$ :RETURN                         'print CIIL command
750 '*************************************************************************
```

FIGURE 4-3 SAMPLE BASIC PROGRAM TO BE USED WITH THE IBM PERSONAL COMPUTER

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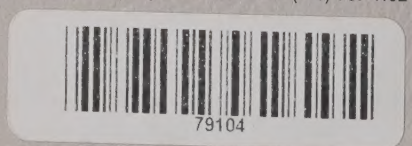

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